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The Effect of AGN Feedback on the Brightest Cluster Elliptical Galaxies

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Abstract. We show the properties of the Bright Central Galaxy (BCG) formed in the center of a Virgo–like cluster simulated using the AMR code RAMSES. We compared 2 models, with and without AGN feedback, showing that only the former can reproduce global properties of BCGs. It is possible to reproduce the stellar mass, the effective radius and the velocity dispersion of early-type galaxies in the field or in groups without considering AGN feedback, but the same properties of early-type galaxies in cluster sized halos are impossible to reproduce without AGN feedback. The strongest constraint comes from abundance matching, for which the stellar-to-halo mass ratio in simulations without AGN feedback appears too large when compared to observations. The kinematical and structural properties of the BCG are different in the two models. Without AGN feedback, we obtain a quickly rotating BCG, with high Sérsic index, a clear mass excess in the center and a very large stellar mass fraction. With AGN feedback, we obtain a slowly rotating BCG, with a significantly cored surface density profile and low stellar mass fraction.

1. Cosmological hydrodynamical simulations of cluster galaxies

We use the AMR code RAMSES (Teyssier 2002) to perform two hydrodynamical cosmological simulations of a Virgo-like cluster of galaxies with a virial mass of $M_{\rm vir} = 10^{14}$ M$_\odot$ and that form within a ΛCDM cosmology. The mass resolution is 8.2×10^6 M$_\odot$ and the spatial resolution is $\sim$500 pc. We model gas dynamics and standard galaxy formation physics, including gas cooling, star formation and supernovae feedback. In one of the runs we neglect the effect of AGN feedback. In the other run we include AGN feedback using a modified version of the Booth & Schaye (2009) model. We study the effect of AGN feedback on the properties of the Brightest Cluster Galaxy (BCG).

1.1. Results

We analyse the masses, effective radii and mean velocity dispersions within the effective radius of the BCGs in our models. A comparison is made with the simulations of Naab et al. (2009) and Feldmann et al. (2010) which reproduce some of the observed properties of field elliptical galaxies and central galaxies in groups without AGN feedback. We also compare our model to a sample of elliptical galaxies at $0.04 < z < 0.08$ (van der Wel et al. 2008) and to four BCGs at $0.07 < z < 0.09$ (Brough et al. 2011). Our

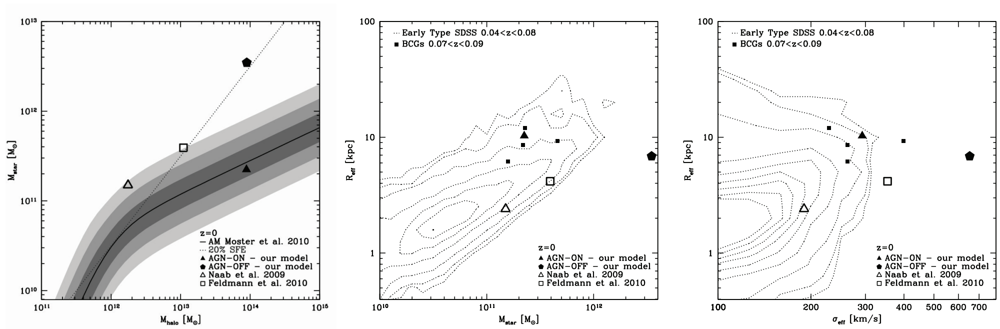

Figure 1. Left panel: Comparison of the stellar-vs-halo mass relation in 4 early-type galaxies from different cosmological simulations (filled and empty black dots). The dotted line is the relation expected for a 20% star formation efficiency from the universal baryon fraction. The solid black line is the prediction from abundance matching (Moster et al. 2010). The grey shaded areas represent the 1σ, 2σ and 3σ scatter bars around the average relation. Center and right panels: mass-size (center) and velocity-size (right) relation of early-type galaxies at redshift $z = 0$ from Sloan data (van der Wel et al. 2008), compared to four early-type galaxies from different cosmological simulations. The black dotted lines are contours of the number of early-type galaxies per bin in the $0.04 < z < 0.08$ sample; going from outside-in we show contours for 5, 10, 30, 100, 200, 300, 400, 500, 600 galaxies per bin. Each bin has a size $\Delta \log(M_{\rm star}) = \Delta \log(R_{\rm eff}) = \Delta \log(\sigma_{\rm eff}) = 0.1$. The four BCGs analysed by Brough et al. (2011) are also shown as black filled squares.

results are summarized in Figure 1. Further results concerning our BCG simulations can be found in Martizzi et al. (2011).

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